SPECIFICATION

SUBSTRATE CONVEYER ROBOT

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a robot for conveying a substrate, for example, a substrate conveyer robot suitable for use in conveying a semiconductor wafer substrate to hand over to a container such as a cassette, and taking it out from the container.

Related Art

Conventionally, there has been a generally used wafer substrate conveyer robot of the belt link type that possesses an arm expansion/contraction mechanism with three arms of a first through a third arm, in which the gear rate of the pulley furnished on the rotation spindle of each arm is 2 : 1 : 2. This type of robot conveys the substrate horizontally by the control of only two axes. One of them is a robot advancing/retreating axis R for linearly advancing and retreating the third arm by the belt link mechanism, and another one is a robot revolving axis θ for revolving the rotary base of the robot. Further, with a lifting/lowering operation of the whole arms, the robot performs the handover and takeout of the substrate to and from the cassette.

In general, a substrate conveyer robot 01 possesses the arm expansion/contraction mechanism composed of three arms 05, 07, 09, and the two control axes, the robot revolving axis θ and the robot advancing/retreating axis R. As illustrated in Fig. 11, the center of the substrate 030 held by a hand 010 fixed on the third arm 09 advances and retreats along a straight line J0 that passes through the center of a rotary

shaft (= a first spindle; this is positioned on the same axis as the robot revolving axis θ) of the first arm 05, thereby the substrate conveyer robot 01 is designed to convey and hand over the substrate 030 only to a cassette 032 that is disposed to face the front thereof toward the line J0. Here, the straight line J0 coincides with the robot advancing/retreating axis R.

The cassette 032 forms in a quadrangle, and permits the substrate 030 to be inserted only from one direction vertical to an aperture plane thereof; and, in case of the conventional robot with two axes, as illustrated in Fig. 11(a) through Fig. 11(c), the robot 010 or cassette 032 has been required to be disposed in such a manner that the center line of the cassette 032 perpendicular to the aperture plane thereof always passes through the robot revolving axis θ (the pivotal center). And, first of all, a rotation base 03 is rotated around the robot revolving axis θ, and the third arm 09 is positioned right in front of the cassette 032. Next, the third arm 09 is moved to advance and retreat linearly along the robot advancing/retreating axis R (the straight line J0), thereby handing over and taking out the substrate 030 to and from the cassette 032. In other words, the control of the rotating movement around the robot revolving axis θ and the control of the advancing and retreating movement along the robot advancing/retreating axis R have been carried out sequentially, and not simultaneously.

As described above, most of the conventional robots possessing two control axes, the robot revolving axis θ and the robot advancing/retreating axis R, were not assumed to combine the control of the rotating movement around the robot revolving axis θ and the control of the advancing and retreating movement along the robot advancing/retreating axis R simultaneously. Therefore, the conventional robots could only convey to hand over and take out the substrate to and from the cassette that is

positioned in a radial manner to (in other words, positioned right in front of) the robot revolving axis θ.

Therefore, in order for the robot to maintain the control to convey to hand over and take out the substrate to and from the cassette, even in case the cassette is positioned so as to face right to an arbitrary straight line deviating from the robot revolving axis θ, there was no other way than to use such a robot that is disclosed in Japanese Patent Laid-Open No. Hei 11(1999) - 33948 Publication. This robot adds one axis to the foregoing two axes (two control axes) to freely control the position and direction of the hand engaged with the last arm in the horizontal plane.

However, the use of the robot disclosed in the above publication required an extra driving source for driving the one axis added, and made the control complicated at the same time, thus raising the cost.

The substrate conveyer robot illustrated in Fig. 11 is a single arm sequence type, possessing one sequence of an arm expansion/contraction mechanism composed of three arms. Also, a double arm sequence type substrate conveyer robot that possesses two sequences (a pair) of bilaterally symmetrical arm expansion/contraction mechanisms has the same problem as described above.

SUMMARY OF INVENTION

The present invention has been made in view of solving the above problems that the conventional substrate conveyer robot possesses, and an object of the invention is to provide a substrate conveyer robot that can hand over and take out a substrate to and from a container disposed in an arbitrary position and direction within an accessible range of the robot hand, with a number of the control axes as smaller as possible, at a low production cost.

To accomplish the foregoing object, according to one aspect of the invention, the substrate conveyer robot is provided with a rotation base 3 driven to rotate by a first motor M1 inside the body of the robot, which has a pivotal center Q, in which a first spindle 4 is protruded in a state indifferent to the rotation of the rotation base 3, which is positioned coaxially with the pivotal center Q on an upper part of the rotation base 3, and is driven to rotate by a second motor M2; one end of a first arm 5 is attached to the first spindle 4; a second spindle 6 is protruded on the other end of the first arm 5 in a state indifferent to the rotation of the first arm 5, which is rotated by a gear rate 2 : 1 by way of pulleys and a timing belt inside the first arm 5, accompanied with the rotation of the first arm 5; one end of a second arm 7 is attached to the second spindle 6; a third spindle 8 is protruded on the other end of the second arm 7 in a state indifferent to the rotation of the second arm 7, which is rotated by a gear rate 1 : 2 by way of pulleys and a timing belt inside the second arm 7, accompanied with the rotation of the second arm 7; a distance between the first spindle 4 and the second spindle 6 is equal to a distance between the second spindle 6 and the third spindle 8; one end of a third arm 9 is attached to the third spindle 8; a hand 10 for holding a substrate is firmly attached on the other end of the third arm 9; and, when the rotation angle of the rotation base 3 is represented by θ and the rotation angle of the first arm 5 is represented by ϕ, a control device is provided which controls the rotation angles θ and ϕ in such a manner that a center point of the substrate held by the hand 10, deviating from the pivotal center Q, moves linearly to the body of the robot on the straight line H in an arbitrary direction within an accessible range of the hand 10, and the substrate is handed over and taken out to and from a container, while the substrate is being rotated.

The substrate conveyer robot with the above construction is the

so-called single arm sequence type substrate conveyer robot having a single sequence of an arm expansion/contraction mechanism that contains the first through the third arms 5, 7, and 9. The control device controls the rotation angle θ of the rotation base 3 provided in the body of the robot and the rotation angle ϕ of the first arm 5, in such a manner that the center point of the substrate held by the hand 10, deviating from the pivotal center Q, moves linearly to the body of the robot on the straight line H in an arbitrary direction within the accessible range of the hand 10, and the substrate is handed over and taken out to and from the container, while the substrate is being rotated. Therefore, when compared with the conventional single arm sequence type substrate conveyer robot, the invention can provide a substrate conveyer robot that can hand over and take out the substrate to and from the container disposed in an arbitrary position and direction within the accessible range of the hand 10 of the robot, without increasing the number of the control axes, at a low production cost.

Further, in the foregoing construction, the control device preferably controls the rotation angles θ and ϕ each so as to satisfy:

$\{m + 2 L \sin(\phi)\} \sin(\theta) = h$ (constant),

where it is assumed that the center point of the substrate deviates from the pivotal center Q by a constant distance h, and moves linearly to the body of the robot on the straight line H in an arbitrary direction within the accessible range of the hand 10, and that the distance between the first spindle 4 and the second spindle 6 and the distance between the second spindle 6 and the third spindle 8 are represented by L, and a distance between the third spindle 8 and the center of the substrate is represented by m. As the result, the combination control of these rotation angles θ and ϕ becomes very simple, in which the center point of the substrate held by the hand 10, deviating from the pivotal center Q, moves linearly to the body

of the robot on the straight line H in an arbitrary direction within the accessible range of the hand 10, and the substrate is handed over and taken out to and from the container, while the substrate is being rotated.

According to another aspect of the invention, the substrate conveyer robot is provided with a rotation base 3 driven to rotate by a first motor M1 inside the body of the robot, which has a pivotal center Q, in which first spindles 4, 4' are protruded in a state indifferent to a rotation of the rotation base 3, which are positioned to be offset outside by an equal distance x symmetrically with respect to the pivotal center Q on an upper part of the rotation base 3, and each are driven to rotate by second motors M2, M2'; one ends of first arms 5, 5' are attached to the first spindles 4, 4'; second spindles 6, 6' are protruded on the other ends of the first arms 5, 5' in a state indifferent to the rotation of the first arms 5, 5', which are rotated each by a gear rate 2 : 1 by way of pulleys and timing belts inside the first arms 5, 5', accompanied with the rotation of the first arms 5, 5'; one ends of second arms 7, 7' are attached to the second spindles 6, 6'; third spindles 8, 8' are protruded on the other ends of the second arms 7, 7' in a state indifferent to the rotation of the second arms 7, 7', which are rotated each by a gear rate 1 : 2 by way of pulleys and timing belts inside the second arms 7, 7', accompanied with the rotation of the second arms 7, 7'; a distance between the first spindles 4, 4' and the second spindles 6, 6' is equal to a distance between the second spindles 6, 6' and the third spindles 8, 8'; one ends of third arms 9, 9' are attached to the third spindles 8, 8'; hands 10, 10' for holding substrates are firmly attached on the other ends of the third arms 9, 9'; centers of the substrates each held by the hands 10, 10' are positioned to be offset inside by an equal distance x to the third spindles 8, 8', in a direction opposite to the direction in which the first spindles 4, 4' are positioned to be offset outside by the equal distance x symmetrically to the

pivotal center Q; and when the rotation angle of the rotation base 3 is represented by θ and the rotation angles of the first arms are each represented by ϕ, ϕ', a control device is provided which controls the rotation angles θ and ϕ, ϕ', in such a manner that center points of the substrates held by the hands 10, 10', deviating from the pivotal center Q, move linearly to the body of the robot on the straight lines H, H' in arbitrary directions within accessible ranges of the hands 10, 10', and the substrates are handed over and taken out to and from a container or containers, while the substrates are being rotated.

The substrate conveyer robot with the above construction is the so-called double arm sequence type substrate conveyer robot having two sequences (a pair) of arm expansion/contraction mechanisms, which contain first through third arms 5, 5', 7, 7', and 9, 9' respectively, in a bilateral symmetry. The control device controls the rotation angle θ of the rotation base 3 provided in the body of the robot and the rotation angles ϕ, ϕ' of the first arms 5, 5', so that the center points of the substrates held by the hands 10, 10', deviating from the pivotal center Q, move linearly to the body of the robot on the straight lines H, H' in arbitrary directions within the accessible ranges of the hands 10, 10', and the substrates are handed over and taken out to and from the container(s), while the substrates are being rotated. Therefore, when compared with the conventional double arm sequence type substrate conveyer robot, the invention can provide a substrate conveyer robot that can hand over and take out the substrates to and from the containers disposed in arbitrary positions and directions within the accessible ranges of the hands 10, 10' of the robot, without increasing the number of the control axes, at a low production cost.

Further, in the foregoing construction, the control device preferably controls the rotation angles θ and ϕ, ϕ' each so as to satisfy:

$$\{m + 2 L \sin(\phi)\} \sin(\theta) = h \text{ (constant)},$$

or

$$\{m + 2 L \sin(\phi')\} \sin(\theta) = h' \text{ (constant)},$$

where it is assumed that the center points of the substrates deviate from the pivotal center Q by constant distances h, h', and move linearly to the body of the robot on the straight lines H, H' in arbitrary directions within the accessible ranges of the hands 10, 10', and that the distance between the first spindles 4, 4' and the second spindles 6, 6', and the distance between the second spindles 6, 6' and the third spindles 8, 8' are represented by L, and a distance before the offset between the third spindles 8, 8' and the centers of the substrates is represented by m. As the result, the combination control of these rotation angles θ and ϕ, ϕ' becomes very simple, in which the center points of the substrates held by the hands 10, 10', deviating from the pivotal center Q, move linearly to the body of the robot on the straight lines H, H' in arbitrary directions within the accessible ranges of the hands 10, 10', and the substrates are handed over and taken out to and from the containers, while the substrates are being rotated.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the present invention will be described in detail based on the following drawings, wherein:

Fig. 1 is a schematic vertical sectional view of a substrate conveyer robot relating to the first embodiment of the invention;

Fig. 2 illustrates the state in which the substrate conveyer robot relating to the first embodiment is used in various operational modes;

Fig. 3 explains the operational mechanism of the substrate conveyer robot relating to the first embodiment;

Fig. 4 illustrates the various operational states of the substrate

conveyer robot relating to the first embodiment in an overlapped manner;

Fig. 5 illustrates the various operational states of the substrate conveyer robot relating to the first embodiment separately by each state;

Fig. 6 is a schematic vertical sectional view of a substrate conveyer robot relating to the second embodiment of the invention;

Fig. 7 illustrates a skeleton in the initial state of the substrate conveyer robot relating to the second embodiment;

Fig. 8 illustrates a skeleton for explaining the operational mechanism of the substrate conveyer robot relating to the second embodiment;

Fig. 9 is a perspective view of the substrate conveyer robot relating to the first embodiment shown in Fig. 1;

Fig. 10 is a perspective view of the substrate conveyer robot relating to the second embodiment shown in Fig .6; and,

Fig. 11 illustrates an example of the conventional substrate conveyer robot.

DETAILED DESCRIPTION OF THE INVENTION

Next, the first embodiment of the invention disclosed in the first and the second claims of the application, illustrated in Fig. 1 through Fig. 5, and Fig. 9, will be explained.

The substrate conveyer robot relating to the first embodiment is the so-called single arm sequence type substrate conveyer robot that possesses one sequence of an arm expansion/contraction mechanism containing three arms of the first through the third arms, which is used, for example, for conveying a semiconductor wafer substrate. Mostly, such a substrate forms in a disk, and has an orientation flat (a part cut off in a straight line on the edge of the disk) that is used for positioning, etc., formed on one part of the

circumference.

As illustrated in Fig. 1, a substrate conveyer robot 1 of the first embodiment is furnished inside a robot body 2 with a rotation base 3 having a pivotal center Q, which is driven and rotated by the first motor M1 via a reduction gear G1. The rotation base 3 is rotated around the pivotal center Q. The first motor M1 is housed and fixed inside an elevation base 55 installed beneath the rotation base 3.

Inside the body of the rotation base 3, a second motor M2 is fixed on the upper part thereof. A first spindle 4 disposed on the same axis as the pivotal center Q, which is driven and rotated by this second motor M2 via a reduction gear G2, protrudes from the upper part of the body of the rotation base 3, in a state independent of the rotation of the rotation base 3. Therefore, the first spindle 4 will revolve by the rotation of the rotation base 3, but the rotation caused by the second motor M2 will not be influenced by the rotation of the rotation base 3.

The first spindle 4 is firmly attached on one end of the first arm 5. And, a second spindle 6 protrudes independently of the rotation of the first arm 5 on the other end of the first arm 5, and the second spindle 6 is rotated by the gear rate of 2 : 1 via pulleys 11, 12 and a timing belt 13 inside the body of the first arm 5, accompanied with the rotation of the first arm 5.

The pulley 11 is made up with the upper part of the rotation base 3 whose diameter is reduced, and this reduced diameter part is intruded inside the first arm 5 so as not to escape therefrom. The reduction gear G2 is received with a spacing from the reduced diameter part. The pulley 12 is made up with the lower part of the second spindle 6 whose diameter is enlarged, and this larger diameter part is received inside the first arm 5 so as not to escape therefrom. The second spindle 6 is formed into a hollow cylinder with a stage. The timing belt 13 is put on between the pulleys 11

and 12, and the gear rate of these pulleys 11 and 12 is 2 : 1.

Therefore, if the first arm 5 is rotated by the angle of ϕ with the first spindle 4, by the rotation of the first spindle 4 that is driven to rotate by the second motor M2, the rotation of the angle ϕ will relatively travel the timing belt 13 on the pulley 12 the same length as the length that the timing belt 13 relatively travels on the pulley 11, so that the amount of rotation of the second spindle 6 caused by this travel of the timing belt 13 will be 2ϕ, which is twice the rotation angle ϕ of the first arm 5 (the first spindle 4), and the rotational direction thereof will be opposite to the rotational direction of the first arm 5.

A smaller diameter part of the second spindle 6, which protrudes from the other end of the first arm 5, is firmly attached on one end of the second arm 7. And on the other end of the second arm 7, a third spindle 8 is provided to project out in a state indifferent to the rotational movement of the second arm 7, wherein the third spindle 8 is rotated at the gear rate of 1 : 2 by way of pulleys 21, 22 and a timing belt 23, inside the second arm 7, accompanied with the rotational movement of the second arm 7. The distance between the second spindle 6 and the third spindle 8 is made identical to the distance between the first spindle 4 and the second spindle 6.

The pulley 21 is made up with a cylindrical part integrally formed with the other end of the first arm 5 that protrudes upward, and this cylindrical part is intruded inside the second arm 7 so as not to escape therefrom. The smaller diameter part of the second spindle 6 is inserted with a spacing to the cylindrical part, and it protrudes out from the other end of the first arm 5 independently of the rotational movement of the first arm 5. The pulley 22 is made up with the lower part of the third spindle 8 whose diameter is enlarged. The third spindle 8 is formed into a hollow

cylinder with a stage, and the larger diameter part (lower part) of the third spindle 8 is received inside the second arm 7 so as not to escape therefrom. The timing belt 23 is put on between the pulleys 21 and 22, and the gear rate of these pulleys 21 and 22 is 1 : 2.

Therefore, if the second arm 7 is rotated by the angle of 2ϕ with the second spindle 6 by the rotation of the second spindle 6, the rotation of the angle 2ϕ will relatively travel the timing belt 23 on the pulley 22 the same length as the length that the timing belt 23 relatively travels on the pulley 21, so that the amount of rotation of the third spindle 8 caused by this travel of the timing belt 23 will be ϕ, that is, half the rotation angle 2ϕ of the second arm 7 (the second spindle 6), and the rotational direction thereof will be opposite to the rotational direction of the second arm 7. This indicates that the third spindle 8 does not change the attitude of its own, even with the rotation of the first arm 5. Moreover, since the distance between the second spindle 6 and the third spindle 8 is the same as the distance between the first spindle 4 and the second spindle 6, the pivot P3 of the third spindle 8 will always be on the straight line J that passes through the pivot P1 of the first spindle 4 (and this pivot P1 coincides with the pivotal center Q). In Fig. 3, for example, when the pivot P2 of the second spindle 6 is transferred to $P2_1$ with the rotation, the pivot P3 of the third spindle 8 is transferred to $P3_1$ with the rotation, but the point $P3_1$ will still be on the straight line J. This straight line J is perpendicular ($\eta = 90°$) to the straight line that connects the pivot P1 of the first spindle 4 and the initial position $P2_0$ of the pivot P2 of the second spindle 6 (refer to Fig. 1, Fig. 3, and Fig 4 (a)). Also, this initial position $P2_0$ is a point to transfer the position in accordance with the rotation angle θ of the rotation base 3 on the x y absolute coordinate, which will be described later.

One end of the third arm 9 is firmly attached on the third spindle 8.

And, the hand 10 for holding the substrate 30 is fixed on the other end of the third arm 9. As described above, since the third spindle 8 does not change the attitude even with the rotation of the first arm 5, the third arm 9 and the hand 10 will not change their attitudes with the rotation of the first arm 5.

In the first embodiment, the pivot (center point) P4 of the substrate 30 held by the hand 10 as well as the pivot P3 of the third spindle 8 is always on the straight line J that passes through the pivot P1 of the first spindle 4 (the pivotal center Q). This constant straight line J forms in a fixed straight line on the relative x' y' coordinate system that is assumed to be on the rotation base 3. The distance R from the pivot P4 of the substrate 30 being always on the straight line J to the pivotal center Q indicates the amount of extension of the arm expansion/contraction mechanism, and is regarded as an important measure for the operational amount of handing over and taking out the wafer substrate 30 to and from the cassette 32 (refer to Fig. 4). Since the amount of extension is determined by the rotational amount of the first arm 5, it can be controlled by controlling the rotational amount of the second motor M2 that drives to rotate the first spindle 4. The straight line J corresponds to the robot advancing/retreating axis R in the substrate conveyer robot 1 possessing the two control axes, namely the robot revolving axis θ and the robot advancing/retreating axis R.

Fig. 3 explains each operation of the rotation base 3 and the arm expansion/contraction mechanism containing three arms from the first to the third 5, 7, and 9, on the x y absolute coordinate that is established on the installation surface of the substrate conveyer robot 1, and also explains the mechanism of the ultimate movement of the pivot P4 of the substrate 30 along the straight line H on this coordinate system as the result of the operation. Fig. 4 illustrates the various operational states of the substrate

conveyer robot 1 to operate based on this mechanism, in an overlapped manner with the elapse of time. Also, Fig. 5 illustrates the same various operational states separately with the elapse of time.

As illustrated in Fig. 3, the straight line H does not pass through the pivot P1 (the pivotal center Q) of the first spindle 4, and deviates from this pivot P1 by a constant distance h. The straight line J, as mentioned above, is a fixed straight line on the relative x' y' coordinate system. Therefore, on the absolute x y coordinate system, the direction of the straight line J is dependent only on the rotation angle θ of the rotation base 3. The pivotal center Q that forms a rotational center of the rotation base 3 corresponds to the robot revolving axis θ in the substrate conveyer robot 1 that possesses the two control axes, the robot revolving axis θ and the robot advancing/retreating axis R, and forms the control axis when controlling the rotation angle θ of the rotation base 3.

Now, on the absolute x y coordinate system, assuming that the rotation angle of the rotation base 3 representing the rotation amount of the straight line J (the rotation amount of the robot hand 10) is given by θ, the rotation angle of the first arm 5 (the first spindle 4) measured on the basis of the straight line P1 $P2_0$ is given by ϕ, the distance between the first spindle 4 and the second spindle 6 (namely, the distance between P1 and P2) = the distance between the second spindle 6 and the third spindle 8 (namely, the distance between P2 and P3) is given by L, the distance between the third spindle 8 and the center of the substrate 30 (namely, the distance between P3 and P4) is given by m, and the distance between the first spindle 4 and the third spindle 8 (namely, the distance between P1(Q) and P3) is given by r, and assuming that the center point P4 of the substrate 30 held by the hand 10, deviating by the constant distance h from the pivotal center Q, makes a linear movement to the robot body 2 on the straight line

H in an arbitrary direction within the accessible range of hand 10, the angle $\angle$ P1 P2 P3 that the first arm 5 and the second arm 7 form is 2ϕ; and therefore, the distance R between the center point P4 of the substrate 30 and the pivotal center Q (that is, the distance between P4 and P1) is represented by:

$$R = m + r = m + 2L\sin(\phi).$$

When representing the center point P4 of the substrate 30 according to the orthogonal coordinate (x, y),

$$P4\,(x, y)$$
$$= P4\,(R\cos(\theta), R\sin(\theta))$$
$$= P4\,[\{m + 2L\sin(\phi)\}\cos(\theta), \{m + 2L\sin(\phi)\}\sin(\theta)].$$

Accordingly, in order for the center point P4 of the substrate 30 to always travel straight on the straight line H being parallel to the axis x, the rotation angles θ and ϕ should be controlled by controlling the rotation amount of the first motor M1 and that of the second motor M2, so as to satisfy the following:

$$\{m + 2L\sin(\phi)\}\sin(\theta) = h \text{ (constant)} \qquad \text{(formula 1).}$$

The control device 40 (refer to Fig. 1) controls each of the rotation amount of the first motor M1 and that of the second motor M2, so that the rotation angles θ and ϕ always satisfy the above formula 1.

Further in this case, as illustrated in Fig. 4 (a) through Fig. 4 (d), and Fig. 5 (a) through Fig. 5 (d), the center point P4 of the substrate 30 moves on the straight line H, while the whole substrate 30 is being rotated around the center point P4. The substrate 30 can conveniently be inserted into the cassette 32 without colliding against or making contacts with the inner wall of the cassette 32 during the insertion, since the outline of the substrate 30 is circular except for the one part (the orientation flat part). The same can be said for taking out the substrate 30 from the cassette 32.

The cassette 32 may be positioned in an arbitrary position and direction, as long as it is within the accessible range of the robot hand 10. Moreover, since it includes a case such that the straight line H used for the insertion of the substrate 30 into the cassette 32 (the travel locus of the substrate 30 during the insertion) does not pass through the pivotal center Q, as illustrated in Fig. 2 (a) through Fig. 2 (c), the wafer substrate 30 can be handed over and taken out, corresponding to various positioning forms of the cassette 32. Besides, in regard to the robot 1 with the configuration illustrated in Fig. 1, since the pivotal center Q, around which all the arms of the robot (the whole arm expansion/contraction mechanism) revolve, and the pivot P1 of the first spindle 4 are made to coincide with each other, the first motor M1 and the second motor M2 should simply be controlled so that the rotation angles θ and ϕ satisfy the very simple formula 1, thus making the control method very simple.

The substrate conveyer robot 1 relating to the first embodiment further possesses an ascent/descent mechanism 50, which lifts and lowers the rotation base 3 and the whole arm expansion/contraction mechanism. The ascent/descent mechanism 50 includes the third motor M3 being a driving source of the mechanism, pulleys 52, 53, and a timing belt 54. The pulleys 52, 53, and the timing belt 54 transmit the output of the third motor M3 to a ball screw mechanism 51. By the rotation of the third motor M3, the ascent/descent mechanism 50 brings up and down an elevation base 55 that contains the first motor M1, thereby lifts and lowers the rotation base 3 that is established on the upper part of the elevation base 55, and the whole arm expansion/contraction mechanism vertically in the Z-axis direction. Therefore, the substrate conveyer robot 1 possesses the robot ascending/descending axis Z as the third control axis, other than the two control axes, the robot revolving axis θ and the robot advancing/retreating

axis R. As the result, the substrate conveyer robot 1 is able to comply with plural cassettes 32 positioned in different height levels.

Since it is configured as described above, the first embodiment yields the following effects.

In the single arm sequence type substrate conveyer robot 1 possessing one sequence of the arm expansion/contraction mechanism that comprises the first through the third arms, 5, 7 and 9, the rotation angle θ of the rotation base 3 that are furnished inside the robot body 2 and the rotation angle ϕ of the first arm 5 are controlled by the control device 40 in such a manner that the center point P4 of the substrate 30 held by the hand 10, deviating from the pivotal center Q, moves linearly to the robot body 2 on the straight line H in an arbitrary direction within the accessible range of the robot hand 10, and the substrate 30, while being rotated, can be handed over and taken out to and from the cassette 32. Therefore, compared with the conventional single arm sequence type substrate conveyer robot, this embodiment provides an inexpensive substrate conveyer robot that can hand over and take out the substrate 30 to and from the cassette 32 being disposed in an arbitrary position and direction within the accessible range of the robot hand 10, without increasing the number of the control axes. Moreover, since the control of the rotation angles θ and ϕ by the control device 40 should only be the control such that these rotation angles θ and ϕ always satisfy the foregoing formula 1, the combination control of these rotation angles θ and ϕ will become extremely simple.

Next, the second embodiment of the invention disclosed in claim 3 and claim 4 of the application will be explained with reference to Fig. 6 through Fig. 8, and Fig. 10.

The substrate conveyer robot relating to the second embodiment, as

illustrated in Fig. 6 and Fig.10, is configured as the so-called double arm sequence type substrate conveyer robot 1' that includes one pair (two sequences) of the arm expansion/contraction mechanisms in a bilateral symmetry, which are composed of three arms, the first arm through the third arm respectively.

In the arm expansion/contraction mechanisms of the arm sequences A and B configuring the double arm sequence, as illustrated in Fig. 6 and Fig. 7, the pivots P1 and P1' of the first spindles 4 and 4' are placed at symmetrical positions to the pivotal center Q of the rotation base 3 to be offset outside by an equal distance x, and the second motors M2 and M2' as the driving sources are furnished to the first spindles 4 and 4', respectively. Also, the center points P4 and P4' of the substrates 30 and 30' each held by the hands 10 and 10' are positioned to be offset inside by the equal distance x to the pivots P3 and P3' of the third spindles 8 and 8', in a direction opposite to the direction in which the pivots P1 and P1' of the first spindles 4 and 4' are placed at the symmetrical positions to the pivotal center Q to be offset outside by the equal distance x to the pivotal center Q.

There are several methods of achieving the configuration such that one ends of the third arms 9 and 9' each are attached to the third spindle 8 and 8', and the hands 10 and 10' for holding the substrates30 and 30' are fastened on the other ends of the third arms 9 and 9', and as described above, the center points P4 and P4' of the substrates 30 and 30' are positioned to be offset inside by the equal distance x to the pivots P3 and P3' of the third spindles 8 and 8'. In short, the offset amount of the centers P4 and P4' of the substrates 30 and 30' to the pivots P3 and P3' of the third spindles 8 and 8' only needs to be set inside to x (in the direction opposite to the direction in which the centers P1 and P1' of the first spindles 4 and 4' are placed to be offset outside to the pivotal center Q). As illustrated in Fig. 7 and Fig. 8,

there is a method of disposing the hands 10 and 10' perpendicularly to the third arms 9 and 9', respectively, and positioning the hands 10 and 10' along the straight line J, which is one of the most comprehensible examples. Here, the straight line J is a line connecting each of the centers P4 and P4' of the substrates 30 and 30' with the pivotal center Q, which corresponds to the robot advancing/retreating axis R as the control axis.

The arm expansion/contraction mechanism of each of the arm sequences A and B in the double arm sequence type substrate conveyer robot 1' of the second embodiment differs from that in the single arm sequence type substrate conveyer robot 1 of the first embodiment in terms of the points mentioned above. However, the configuration and the operation do not basically differ from those of the first embodiment. The movements of the center points P4 and P4' of the substrates 30 and 30' on the straight line J are also the same as those of the first embodiment. The rotation base 3 is shared by the arm expansion/contraction mechanisms of the arm sequences A and B for the revolution of the whole arm expansion/contraction mechanisms, and the rotation angle θ around the pivotal center Q (the robot revolving axis θ) of the rotation base 3 becomes the revolution angle of each of the arm expansion/contraction mechanisms as it is.

As mentioned above, the movement of the arm expansion/contraction mechanism of each of the arm sequences A and B in the double arm sequence type substrate conveyer robot 1' of the second embodiment is the same as that of the arm expansion/contraction mechanism in the single arm sequence type substrate conveyer robot 1 of the first embodiment. The arm expansion/contraction mechanisms of the arm sequences A and B share the pivotal center Q and use it alternately, thereby each being able to convey the substrates 30 and 30' toward the cassette 32, while the arm expansion/contraction mechanisms each rotate

the substrates 30 and 30' independently alternately and move them on the straight lines H and H' deviating from the pivotal center Q, which extend toward the aperture plane of the cassette 32. Naturally, this robot is able to perform a conveyance movement such that the center points P4 and P4' of the substrates 30 and 30' move on the straight line J passing through the pivotal center Q, in the same manner as the conventional substrate conveyer robot.

In regard to the arm expansion/contraction mechanisms of the arm sequences A and B in the double arm sequence type substrate conveyer robot 1', the setting of the offset from the pivotal center Q of the pivots P1 and P1' of the first spindles 4 and 4' to the amount described above, satisfies the following formulas, in the same manner as the single arm sequence type substrate conveyer robot 1:

$$\{m + 2 L \sin(\phi)\} \sin(\theta) = h \text{ (constant)} \qquad \text{(formula 1)}$$

or,

$$\{m + 2 L \sin(\phi')\} \sin(\theta) = h' \text{ (constant)} \qquad \text{(formula 1')},$$

where it is assumed that the distance before the offset between the third spindles 8 and 8' and the centers of the substrates 30 and 30' is represented by m.

The control device 40' only needs to control the first motor M1 and the second motor M2, and the first motor M1' and the second motor M2', by turns, so that the rotation angle θ of the rotation base 3 and the rotation angles ϕ and ϕ' of the first arms 5, 5' always satisfy the above formula 1 and formula 1'. Thus, the arm expansion/contraction mechanism of the arm sequence A can take out the unprocessed substrate 30 from the cassette 32 that is positioned in an arbitrary position and direction within the accessible range of the hands 10 and 10', and the arm expansion/contraction mechanism of the arm sequence B can return the processed substrate 30' to

the cassette 32 by turns. Off course, two cassettes can be used, one of which is used for containing unprocessed substrates 30, and another of which is used for containing processed substrates 30.

Each of the members constituting the arm expansion/contraction mechanism of the arm sequence B and the other members is given the mark (') on the symbol attached to each of the corresponding members constituting the arm expansion/contraction mechanism of the arm sequence A and the other corresponding members, thereby further detailed explanations of the double arm sequence type substrate conveyer robot 1' of the second embodiment will be omitted.

Being configured as mentioned above, the second embodiment yields the following effects.

In the double arm sequence type substrate conveyer robot 1' possessing symmetrically two sequences (a pair) of the arm expansion /contraction mechanisms composed of the first through the third arms 5, 5', 7, 7', and 9, 9', the rotation angle θ of the rotation base 3 that are furnished inside the robot body 2 and the rotation angles ϕ and ϕ' of the first arms 5, 5' are controlled by the control device 40' in such a manner that the center points P4 and P4' of the substrates 30 and 30' held by the hands 10 and 10', deviating from the pivotal center Q by the constant distances h and h', move linearly each to the robot body 2 on the straight lines H and H' in arbitrary directions within the accessible ranges of the hands 10 and 10', and the substrates 30 and 30', while being rotated, can be handed over and taken out to and from the cassette(s) 32. Therefore, compared with the conventional double arm sequence type substrate conveyer robot, the second embodiment provides an inexpensive substrate conveyer robot 1' that can hand over and take out the substrates 30 and 30' to and from the cassette(s) 32 being disposed in arbitrary positions and directions within the accessible

ranges of the robot hand 10 and 10' without increasing the number of the control axes.

Besides, since the control of the rotation angles θ and ϕ, ϕ' by the control device 40' should only be the control such that these rotation angles θ and ϕ, ϕ' always satisfy the foregoing formula 1 and formula 1', the arm expansion/contraction mechanism of each of the arm sequences A and B is able to employ a common control method, thus making the combination control of these rotation angles θ and ϕ, ϕ' extremely simple.